§28. Basic Design of Microwave Blast Furnace - Repose Angle for Powder Iron Ore Mined in Robe River -

Kashimura, K., Sato, M.

The new blast furnace has been studied. The design was based on conventional shaft furnace. The furnace employed the microwave heating and advantages of the furnace are many. The study is on scale-up stage. The microwave blast furnace needs an ability providing 20 ton pig irons per day. The furnace must be designed based on thermodynamics, microwave engineering and particular media mechanics on the stage. The microwave blast furnace made pig irons from powdery ores as FASTMET and Hi-QUIP method already did. Iron ores mined in Robe River (Australia) were employed for the new method. But a flow of the powdery iron ores was not understood.
The powder flow was controlled by their weight. Repose angle, wall friction angle and exit velocity expressed characters of powder flow for the case.

Powdery iron ores mined in Robe River, Australia were employed as a sample. The powder is an unavoidable by-product in the mining. These iron ores are traded at a low price because they include certain crystal water. Including the crystal water is an advantage for the microwave heating.
The powdery samples were agitated because the flow changes their characters when the size distribution was different. The particle size was measured using meshes. These meshes were divided into 4 types by sizes: fine: the powder sieved to 1.0 mm mesh, small: the powder remaining between 1.0 mm and 2.0 mm meshes, medium: the powder remaining between 2.0 mm and 5.0 mm meshes and large: the powder remaining over 5.0 mm meshes.
Injection method was employed in this paper. A funnel (bore diameter: φ12 mm, height: 70 mm) was used to inject the sample. The fennel was set 300 mm above a steel sheet (300 mm×400 mm, thickness: 1 mm). The system was set up in the laboratory to remove accidental errors. The powder was thrown into the funnel and passed through the bore. The powder corn formed certain gradient in response to their size distribution. The height and diameter of the base circles were measured for each cone. The gradient was defined as repose angle. An uncertainty was estimated by measuring ten times for a cone.
A wall friction angle was measured to design a microwave blast furnace. The angles changed their values in response to a coefficient of friction for wall-powder interface. An iron plate was employed in this study. It was polished with an ethanol. The plate was covered with powders and the thickness of the powdery phase was 10.0 mm. The plate edge was moved up and the slope gradient was controlled. The angle was defined as wall friction angle. The measurement was carried out in the laboratory to remove the effect of wind.

The repose angle has been studied using an injection method for iron ore powders mined in Robe River. The basic shape of the microwave blast furnace was discussed from powdery flow perspective. Results of the measurement are as follows.
1. The repose angle is 19.8-degree and the fine particle increased the angle. (as shown in Fig. 1)
2. The wall friction angle is 24.2-degree.
3. Each powder behaves individually for their sizes (as shown in Fig. 2)
The powder flow is difficult to control by these angles. Microwave blast furnace should control the powder flow using funnels. The hearth angle should be under 19.8-degree.

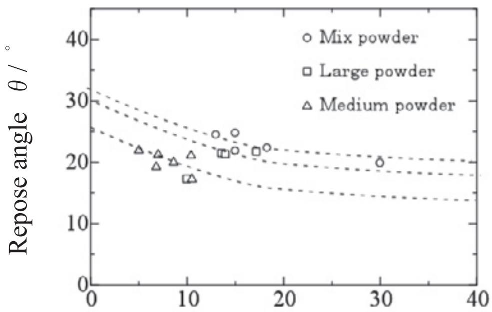

Fig.1 Dependence of repose angle (θ / °) against diameters of base circles of cones (D / mm) plots for size of the Robe River ore powder.

Fig.2 Photo of powders in wall friction angle. Fine powder attached to the wall and large medium and small powder slithered well.